Journal of Educational Sciences
Journal homepage: https://jes.ejournal.unri.ac.id/index.php/JES

P-ISSN 2581-1657
E-ISSN 2581-2203

Needs Analysis for Developing Project-Based Learning E-Modules on the Human Respiratory System for Class XI Phase F Students

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ARTICLE INFO

Article history:

Received: 04 Dec 2025
Revised: 17 Jan 2026
Accepted: 27 Feb 2026
Published online: 05 March 2026

Keywords:

Critical Thinking,
E-module,
Needs analysis,
Project-based learning,
Respiratory system

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Article Doi:

https://doi.org/10.31258/jes.10.3.p.199-211

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A B S T R A C T

This study aims to analyze the need for developing a Project-Based Learning (PjBL)-based e-module on the human respiratory system to strengthen senior high school students' critical thinking skills. The needs analysis was carried out through questionnaires distributed to students and biology teachers. Findings reveal that students frequently encounter difficulties in understanding respiratory system concepts when learning is limited to verbal explanations or textbook-based materials. Students also expressed a preference for digital learning resources equipped with visual representations, videos, practical tasks, and clearly structured learning stages. Biology teachers emphasized the urgency of providing digital media aligned with the Merdeka Curriculum that support collaborative activities and the development of higher-order thinking skills. They also agreed that a PjBL-based e-module has the potential to enhance students' motivation, engagement, and conceptual understanding of the respiratory system. Therefore, the development of a PjBL-based e-module is considered necessary as an interactive and effective learning medium that accommodates both student and teacher needs while promoting meaningful learning and critical thinking.

1. Introduction

Education plays a critical role in strengthening human resource quality, especially in preparing individuals to respond to the increasingly complex demands of the twenty-first century. The Indonesian government continues to introduce various initiatives to improve educational quality, grounded in Law No. 20 of 2003 on the National Education System. This regulation states that education aims to develop learners into knowledgeable, innovative, ethical, and socially responsible individuals (Kemendikbud, 2003). In support of this mandate, the Merdeka Belajar

program was introduced to provide schools with greater autonomy in designing learning experiences that align with learners' characteristics, needs, and local contexts (Kemendikbudristek, 2020). The Merdeka Belajar framework encourages schools to adopt student-centered learning approaches that promote active participation and independent thinking. Project-Based Learning (PjBL) is one of the learning models considered highly relevant to this paradigm. Through contextual and meaningful project tasks, PjBL promotes deeper conceptual understanding and the development of essential skills (Almulla, 2020; Ferreira & Canedo, 2020). Numerous studies indicate that PjBL effectively enhances critical thinking, collaboration, problem solving, and learner responsibility skills that are aligned with twenty-first-century competencies (Sri Handayani et al., 2025; Thornhill-Miller et al., 2023).

In biology education, particularly the human respiratory system, students often face difficulties because many concepts involve abstract and microscopic processes. These challenges are compounded when learning depends solely on lecture-based explanations or textbook readings. Thus, instructional media that can present biological processes visually and interactively are essential. Electronic modules (e-modules) have emerged as a promising innovation, integrating multimedia elements such as animations, videos, and interactive activities that help students understand complex biological mechanisms more concretely (Osmizein & Iskarni, 2022; Al-Rahmi et al., 2020).

E-modules offer several advantages, including accessibility, flexibility for self-paced learning, and the integration of interactive features that increase student motivation and engagement. Empirical evidence shows that e-modules contribute to improved learning outcomes across various biology topics (Delita & Berutu, 2022; Mahendri et al., 2022). Moreover, by linking theoretical concepts with real-life applications through case studies and simulations, e-modules support meaningful and contextual understanding (Aulia et al., 2023; Herlina & Abidin, 2024). They also offer environmentally friendly benefits by reducing reliance on printed materials (Adeningsih et al., 2024).

However, integrating digital learning media into classroom practice still faces several obstacles. Limited availability of interactive digital resources forces many teachers to maintain conventional teaching approaches (Pratama et al., 2024; Saputra & Octavia, 2024). Teacher-centered instruction continues to dominate, resulting in limited student involvement and fewer opportunities for inquiry-based learning (Arief A et al., 2024). In addition, disparities in technological access particularly in rural areas pose challenges for the optimal use of digital tools (Diana et al., 2022; Rukun, 2020). Many teachers also require greater competence in designing and implementing e-modules based on innovative pedagogical models such as PjBL (Muzijah et al., 2020; Selano et al., 2024).

These issues highlight a substantial gap between the expectations of twenty first century learning, which emphasizes technology integration and higher order thinking, and the realities encountered in biology classrooms today. Addressing this gap requires a systematic needs analysis to determine the feasibility and urgency of

developing PjBL-based e-modules tailored to the characteristics of Grade XI Phase F students. Therefore, this study aims to analyze the needs, challenges, and opportunities associated with the development of a PjBL-based e-module on the human respiratory system. The needs analysis focuses on learner characteristics, teacher readiness, technological infrastructure, and alignment with the Merdeka Belajar curriculum. The results are expected to provide a strong foundation for designing an interactive e-module capable of enhancing students' critical thinking skills and supporting meaningful biology learning.

2. Methodology

This study employed a qualitative research design aimed at gathering information necessary for analyzing the needs related to the development of an electronic module (e-module). The needs analysis focused on identifying general learning activities, students' experiences and perceptions of e-modules, expectations regarding digital learning resources, and specific requirements for an e-module designed using the Project-Based Learning (PjBL) approach (Fikri et al., 2026).

Participants

The population of this study consisted of students and biology teachers. The student participants were Grade XI Phase F learners at SMA Negeri 1 Mojolaban during the 2024/2025 academic year. The research sample included one class, namely Grade XI F, comprising 43 students. In addition, the teacher sample consisted of 10 biology teachers selected from public and private senior high schools in Sukoharjo and the surrounding areas.

Data Collection Procedures

Data were collected through interviews and questionnaires to obtain information regarding learning challenges and the instructional materials currently used. The needs analysis questionnaire was distributed online via Google Forms to 43 students and 10 teachers. Data collection was carried out in August 2025.

Instruments

The questionnaire consisted of 11 closed-ended items for students and 7 for teachers, focusing on perceptions of current learning conditions, expectations for e-module use, and requirements for developing a PjBL-based e-module on the human respiratory system. Content validity was established through expert judgment by biology education experts, and revisions were made based on their feedback prior to data collection (Gusman et al., 2026).

Data Analysis

The data obtained from the closed-ended questionnaire items were analyzed using descriptive statistics in the form of percentage calculations. The percentage of each response category was determined using the following formula:

$$P = \frac{n}{N} X\ 100\ \%$$

where:
P = percentage value
n = total score obtained
N = maximum possible score (Arikunto, 2010)

In addition to quantitative analysis, responses from open-ended questionnaire items were analyzed using a qualitative descriptive approach. The analysis was conducted through several stages: (1) collecting and organizing all open-ended responses, (2) repeatedly reading the responses to gain familiarity with the data, (3) identifying and grouping similar responses into categories based on recurring ideas, and (4) interpreting the categories to identify dominant themes related to participants' needs and expectations. To support this qualitative analysis, a word cloud generator was used as an analytical tool to visualize the frequency of keywords appearing in the responses. The word cloud highlighted dominant terms and recurring patterns, thereby supporting thematic categorization and facilitating the interpretation of qualitative data from both students' and teachers' perspectives.

3. Results and Discussion

Data for this study were collected by distributing an online needs-analysis questionnaire to 43 Grade XI Phase F students at SMA Negeri 1 Mojolaban and 10 biology teachers from several senior high schools in Sukoharjo Regency and surrounding areas. The questionnaire was administered via Google Forms and shared through the WhatsApp application to facilitate efficient participation. The primary objective of this research was to gather and analyze information regarding students' and teachers' needs in relation to the development of a Project-Based Learning (PjBL) e-module for teaching the human respiratory system in senior high schools. This study focused on the initial stage of e-module development, particularly the data-gathering phase, which serves to identify the essential components required in designing a PjBL-based e-module that is relevant, interactive, and aligned with the characteristics of students and the instructional needs of teachers. The results of the needs-analysis questionnaire completed by 43 Grade XI Phase F students regarding the development of a respiratory system e-module are summarized in Table 1.

Table 1. Summary of the Results of the Respiratory System E-Module Needs Questionnaire (Students, n = 43)

No	List of Statements	Respondents' Answers (%)
1	I feel that the respiratory system material is quite difficult to understand only through textbooks.	SS = 16.3%; S = 72.1%; TS = 11.6%; STS = 0%
2	I don't really understand biology material just from lectures or explanations from the teacher.	SS = 16.3%; S = 65.1%; TS = 18.6%; STS = 0%
3	The Biology textbook I used was not very interesting.	SS = 11.6%; S = 65.1%; TS = 23.3%; STS = 0%
4	I am more interested in learning using digital media such as e-modules.	SS = 14.0%; S = 53.5%; TS = 30.2%; STS = 2.3%

5	I have used e-modules when studying Biology. (n = 42)	SS = 7.1%; S = 73.8%; TS = 16.7%; STS = 2.4%
6	I wish there was a special e-module that discussed the respiratory system with practice.	SS = 27.9%; S = 65.1%; TS = 7.0%; STS = 0%
7	I would like to have a dedicated e-module that discusses the respiratory system interactively.	SS = 32.6%; S = 60.5%; TS = 7.0%; STS = 0%
8	I find it easier to understand the material if it is accompanied by pictures, videos, or animations.	SS = 55.8%; S = 44.2%; TS = 0%; STS = 0%
9	I want to learn Biology through project activities or hands-on practice.	SS = 34.9%; S = 58.1%; TS = 4.7%; STS = 2.3%
10	I want to be able to access Biology materials anytime and anywhere through digital devices.	SS = 34.9%; S = 65.1%; TS = 0%; STS = 0%
11	I feel that learning Biology will be more interesting if we use e-modules that meet our expectations.	SS = 30.2%; S = 65.1%; TS = 4.7%; STS = 0%

In addition to identifying students' learning difficulties, the questionnaire also explored students' expectations regarding the features that should be included in a respiratory system e-module. A summary of the expected features is presented in Table 2.

Table 2. Expected Features in the Respiratory System E-Module (n = 43)

No	Expected Features	Number (of Respondents)
1	Easy to understand explanation of the material	42
2	Pictures and illustrations of the respiratory system	38
3	Video/animation of the breathing process	36
4	Simple project or experiment activities	31
5	Practice questions and quizzes	35
6	Project-based group assignments	14
7	Can be accessed via cellphone/laptop	36
8	Other	2

Furthermore, students were asked about their preferred ways of learning Biology to better understand their learning tendencies. The distribution of students' preferred learning methods is shown in Table 3.

Table 3. Students' Preferred Ways of Learning Biology (n = 43)

No	How to Learn	Number (of Respondents)
1	Just listen to the teacher's explanation	28
2	Learn from printed books	17
3	Using e-modules or digital media	30
4	Working on projects or hands-on practice	31

Based on the needs-analysis questionnaire completed by 43 students, a comprehensive overview was obtained regarding their expectations for the development of an e-module on the human respiratory system. Overall, students expressed a strong demand for digital learning resources that are interactive, accessible, and capable of supporting deeper conceptual understanding. A large majority of students reported that the respiratory system was difficult to understand when taught solely through textbooks, with 88.4% selecting *Strongly Agree* or *Agree*. This finding is reinforced by the 81.4% who stated that they struggled to

understand the material when instruction relied exclusively on lectures. These results indicate that conventional instructional methods are not fully effective for supporting comprehension of abstract biological concepts.

Student motivation also appears to be affected by the limitations of current learning materials. A total of 76.7% of students stated that their Biology textbooks were uninteresting, suggesting that reliance on printed materials alone may hinder learning engagement. In contrast, students demonstrated greater interest in digital learning, with 67.5% expressing a desire to use e-modules, although only 80.9% had previously encountered such resources. Support for developing an e-module specifically designed for the respiratory system was remarkably strong. Ninety three percent of students agreed that the e-module should include practical or project-based activities, and the same percentage emphasized the need for a clear and well structured presentation of content. These responses indicate that students expect the e-module to not only deliver material but also foster active and meaningful learning experiences.

These findings suggest that the high demand for a PjBL-based e-module is driven by students' preference for active and meaningful learning experiences. The strong inclination toward project-based activities reflects the core principles of Project-Based Learning, which emphasize student engagement through problem solving, collaboration, and the exploration of real-world contexts (Omelianenko & Artyukhova, 2024). Furthermore, students' preference for visual and audiovisual learning materials is consistent with multimedia learning theory, which states that learning is more effective when information is presented through the integration of verbal and visual channels. The emphasis on accessibility indicates students' readiness for flexible, technology-enhanced learning environments that support self-directed learning (Sirait & Maulida, 2023). Collectively, these findings indicate that the development of a PjBL-based e-module has the potential to foster higher-order thinking skills (HOTS) by promoting analysis, creativity, and problem-solving rather than passive memorization (Satria et al., 2024).

The analysis of desired e-module features further strengthens these findings. The most frequently selected components were easy to understand explanations (42 students), visuals such as illustrations and images (38 students), videos or animations (36 students), accessibility via mobile phones or laptops (36 students), and practice questions or quizzes (35 students). Simple project-based tasks were selected by 31 students, emphasizing the relevance of incorporating Project-Based Learning (PjBL). Students' learning preferences also show a shift toward more interactive and student-centered approaches. A significant number preferred learning through e-modules or digital media (30 students) and through project or practical activities (31 students), compared with traditional methods such as listening to the teacher's explanations (28 students) or reading printed textbooks (17 students).

Overall, the results reveal a substantial need for an interactive, visually enriched, and project-based e-module on the human respiratory system that is easily accessible through digital devices. These findings underscore the urgency of

developing a PjBL-based e-module as an instructional innovation aligned with students' learning needs and the competencies required in twenty-first-century education. To complement the student needs analysis, a questionnaire was also administered to Biology teachers to identify their perceptions and readiness regarding the use of e-modules and the PjBL approach. The summary of teachers' responses is presented in Table 4.

Table 4. Summary of Questionnaire Results (n=10)

No	Statement	SS	S	TS	STS	SS (%)	S (%)	TS (%)	STS (%)
1	Respiratory system material difficult understood if only oral/book text	4	6	0	0	40%	60%	0%	0%
2	E-module interactive increase interest in learning	5	5	0	0	50%	50%	0%	0%
3	Requires media flexible daring/luring	7	3	0	0	70%	30%	0%	0%
4	Difficulty find PjBL media	2	4	4	0	20%	40%	40%	0%
5	Need guidance The use of e-modules	3	7	0	0	30%	70%	0%	0%
6	Ready using e-modules in accordance curriculum	6	4	0	0	60%	40%	0%	0%
7	Difficulty find PjBL media (duplication)	2	5	3	0	20%	50%	30%	0%

Teachers were also asked to indicate the features they expected to be included in an effective Biology e-module. The expected features of the e-module based on teachers' responses are summarized in Table 5.

Table 5. Feature Expectations in E-Modules (n=10)

No	Feature	Amount	Percentage
1	Interactive materials	8	80%
2	Video/animation of the breathing process	10	100%
3	Project-based LKPD	7	70%
4	Digital evaluation/quiz	6	60%
5	Additional learning resource links	6	60%
6	Instructions for use for teachers	5	50%

In addition, teachers provided input regarding the learning models they considered most appropriate for developing students' competencies in Biology learning. The preferred learning models identified by teachers are presented in Table 6.

Table 6. Desired Learning Model

No	Learning model	Amount	Percentage
1	Critical, creative, collaborative skills (4C)	10	100%
2	Model modern (PjBL, PBL, STEM)	3	30%
3	Integrating HOTS	4	40%
4	Emotional involvement	1	10%

Teachers were also given the opportunity to provide open-ended suggestions related to the development of the e-module. A summary of these suggestions is presented in Table 7.

Table 7. Open Suggestions

No	Respondents' Suggestions
1	E-modules can be applied anywhere
2	Interactive and engaging modules
3	Accommodating diverse student characters
4	Loading text, images, animations, videos, interactive quizzes
5	Contains examples of daily life and health
6	Equipped with animations and learning videos
7	Easy to understand
8	Updated material
9	Connect to the internet for additional resources

The results of the questionnaire analysis show that students have a strong need for the development of an interactive and easy-to-understand Biology e-module on the human respiratory system, supported by various multimedia features. Most students reported that the material is difficult to comprehend when delivered only through verbal explanations or textbooks, indicating the need for clearer, more visual, and systematically organized content. This condition supports the relevance of cognitive load theory, which emphasizes that complex information must be presented in a concise, structured manner that aligns with learners' cognitive development levels (Sweller, 2011).

Students' preference for images, illustrations, and diagrams also highlights the crucial role of visualization in understanding abstract biological concepts, such as the mechanism of gas exchange in the alveoli or the movement of the diaphragm during inspiration and expiration. These findings are consistent with the multimedia principle, which states that combining visual and verbal information can significantly enhance conceptual comprehension (Mayer, 2009). Additionally, students expressed strong interest in video and animation features, suggesting that audiovisual media are highly effective in visualizing dynamic biological processes. This preference is supported by dual coding theory, which proposes that

information processed simultaneously through visual and verbal channels is easier for learners to understand and retain (Paivio, 2007).

Beyond visual supports, students also demonstrated a clear need for applied learning activities, such as project-based worksheets, simple laboratory tasks, and digital assessments. These preferences reflect their desire for learning experiences that not only promote understanding but also foster critical thinking, creativity, and problem-solving skills. This aligns closely with the principles of Project-Based Learning (PjBL), which emphasizes inquiry, collaboration, and the creation of meaningful learning products key components in developing 21st-century competencies (Bell, 2010). Within the context of the Merdeka Curriculum, these findings become even more relevant, as the curriculum encourages flexible learning opportunities, independent study habits, and the development of the Pancasila Student Profile (Syafwa et al., 2025). Overall, the questionnaire results indicate that the development of a PjBL-based Biology e-module is highly aligned with both curriculum demands and students' actual learning preferences. An e-module that integrates clear explanations, multimedia elements, project-based tasks, and digital assessments is expected to enhance student motivation and provide a more comprehensive understanding of respiratory system concepts (Wahyuni et al., 2025).

Despite these meaningful findings, several limitations of this study should be acknowledged. The number of respondents was relatively limited and drawn from a specific school context, which may restrict the generalizability of the findings to broader educational settings. Furthermore, although open ended responses were analyzed using a word cloud generator to identify dominant keywords and patterns, this approach does not fully replace in-depth qualitative analysis methods, such as thematic coding or interviews. Therefore, the findings should be interpreted with caution, and future research is recommended to involve a wider range of participants and employ more comprehensive qualitative techniques to enhance the rigor and generalizability of the results.

4. Conclusion

The findings of the needs analysis confirm a significant demand for the development of a Project-Based Learning (PjBL)-based e-module on the human respiratory system. Students expressed a notable need for digital learning materials that present concepts in a clear and engaging manner, supported by visual media and practical activities that promote deeper understanding. The limitations of conventional teaching approaches, particularly those relying solely on lectures and textbooks, further reinforce the need for interactive and contextualized learning resources. Teachers also acknowledged the importance of implementing e-modules to improve students' critical thinking skills, in line with the competencies emphasized in the Merdeka Curriculum. Moreover, the PjBL model was considered appropriate for integration into the e-module because of its ability to foster active participation, creativity, and problem-solving skills. In conclusion, the strong and consistent demand identified from both students and teachers highlights the urgency

and relevance of developing a PjBL-based e-module to enhance the quality of Biology instruction and support improved student learning outcomes.

Acknowledgement

The author extends profound appreciation to the school institution for granting permission and providing the necessary facilities to carry out this research. Sincere gratitude is also addressed to the biology teachers whose support and cooperation greatly contributed to the implementation of the learning activities. The author further acknowledges the participation of all students involved in this study, whose responses and engagement were essential to the completion of the research. Deepest appreciation is additionally conveyed to the academic advisor for the guidance, constructive input, and continuous support throughout the preparation and completion of this article.

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How to cite this article:

Sukatni., Karyanto, P., & Prayitno, B. A. (2026). Needs Analysis for Developing Project-Based Learning E-Modules on the Human Respiratory System for Class XI Phase F Students. *Journal of Educational Sciences*, *10(3)*, 199-211.